

## Claims

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A method for forming an alloy layer of silicon carbon on a silicon containing substrate comprising the steps of:
  - placing a wafer having a single crystalline silicon containing surface into a UHV CVD chamber,
  - heating said silicon containing surface to a temperature in the range from about 475° - 850° C, and
  - flowing a silicon containing gas and a carbon containing gas over said silicon containing surface whereby said silicon carbon alloy layer is formed.
2. The method of claim 1 wherein said UHV CVD chamber has a base pressure below  $10^{-8}$  Torr.
3. The method of claim 1 wherein said carbon containing gas includes gas molecules having at least two carbon atoms.
4. The method of claim 1 wherein the oxygen in said silicon carbon layer is less than  $1 \times 10^{17}$  atoms/cc.

5. The method of claim 1 wherein said carbon containing gas is selected from the group of molecules containing unsaturated double or triple carbon-carbon bonds.
6. The method of claim 1 wherein said carbon containing gas is selected from the group consisting of ethylene, acetylene, propylene, butylene, pentene and mixtures thereof.
7. The method of claim 1 wherein said flowing gas is at a pressure in the range from about 1 to 50 millitorr.
8. The method of claim 1 wherein said flowing gases contain less than 1 ppm of contaminant gases containing oxygen.
9. The method of claim 1 wherein said carbon from said carbon containing gas is incorporated into said alloy crystal lattice substitutionally whereby said carbon is electrically active.
10. The method of claim 1 wherein said step of placing a wafer into said UHV CVD chamber includes placing a plurality of wafers.
11. The method of claim 1 wherein said step of flowing includes flowing a dopant containing gas selected from the group consisting of diborane, phosphine, arsine and mixtures thereof.

12. The method of claim 1 wherein said silicon carbon alloy is single crystalline and has an oxygen concentration of less than  $1 \times 10^{17}$  atoms/cc.
13. The method of claim 1 wherein said silicon carbon alloy is polycrystalline and has an oxygen concentration of less than  $1 \times 10^{17}$  atoms/cc..
14. A method for forming an alloy layer of silicon germanium carbon on a silicon containing substrate comprising the steps of:
- placing a wafer having a single crystalline silicon containing surface into a UHV CVD chamber,
  - heating said silicon containing surface to a temperature in the range from about  $350^{\circ}$  -  $850^{\circ}$  C, and
  - flowing a silicon containing gas, a germanium containing gas and a carbon containing gas over said silicon containing surface whereby said silicon germanium carbon alloy layer is formed.
15. The method of claim 14 wherein said UHV CVD chamber has a base pressure below  $10^{-8}$  Torr.
16. The method of claim 14 wherein said carbon containing gas includes gas molecules having at least two carbon atoms.

17. The method of claim 14 wherein oxygen in said silicon carbon layer is less than  $1 \times 10^{17}$  atoms/cc.
18. The method of claim 14 wherein said carbon containing gas is selected from the group of molecules containing unsaturated double or triple carbon-carbon bonds.
19. The method of claim 14 wherein said carbon containing gas is selected from the group consisting of ethylene, acetylene, propylene, butylene, pentene and mixtures thereof.
20. The method of claim 14 wherein said flowing gas is at a pressure in the range from about 1 to 50 millitorr.
21. The method of claim 14 wherein flowing gases contain less than 1 ppm of contaminant gases containing oxygen.
22. The method of claim 14 wherein said carbon from said carbon containing gas is incorporated into said alloy crystal lattice substitutionally whereby said carbon is electrically active.
23. The method of claim 14 wherein said germanium from said germanium containing gas is incorporated into said alloy crystal lattice substitutionally whereby said germanium is electrically active.

24. The method of claim 14 wherein said carbon from said carbon containing gas and germanium from said germanium containing gas are incorporated into said alloy crystal lattice substitutionally whereby both said carbon and said germanium are electrically active.

25. The method of claim 14 wherein said step of placing a wafer includes placing a plurality of wafers into said UHV CVD chamber.

26. The method of claim 14 wherein said step of flowing includes flowing a dopant containing gas selected from the group consisting of diborane, phosphine, arsine and mixtures thereof.

27. The method of claim 14 wherein said silicon germanium carbon alloy is single crystalline and has an oxygen concentration of less than  $1 \times 10^{17}$  atoms/cc.

28. The method of claim 14 wherein said silicon germanium carbon alloy is polycrystalline and has an oxygen concentration of less than  $1 \times 10^{17}$  atoms/cc.

29. A layered structure comprising:

a substrate having an upper surface of single crystalline Si, and

a layer of SiC over said upper surface,

said Si/SiC layer interface having an abrupt change in C concentration of more

than  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about

60 Å,

and wherein the oxygen in said SiC layer is less than  $1 \times 10^{17}$  atoms/cc.

30. The layered structure of claim 29 wherein said silicon carbon alloy is single crystalline.

31. The layered structure of claim 29 wherein said silicon carbon alloy is polycrystalline.

32. The layered structure of claim 29 further including a layer of Si over said layer of SiC, said SiC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.

33. The layered structure of claim 29 wherein said layer of SiC includes a p-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc and wherein said p-type dopant profile can withstand furnace anneals to temperatures of 850° C and rapid thermal anneal temperatures to 1000° C.

34. The layered structure of claim 29 wherein said layer of SiC includes a n-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc.

35. The layered structure of claim 33 further including a layer of Si over said layer of p-type doped SiC, said p-type doped SiC/Si layer interface having an abrupt change in C concentration

above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.

36. The layered structure of claim 35 wherein said p-type doped SiC/Si layer interface having an abrupt change in dopant concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å.

37. The layered structure of claim 34 further including a layer of Si over said layer of n-type doped SiC, said n-type doped SiC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.

38. The layered structure of claim 37 wherein said n-type doped SiC/Si layer interface having an abrupt change in dopant concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å.

39. The layered structure of claim 29 further including a layer of SiGe over said layer of SiC, said SiC/SiGe layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

40. The layered structure of claim 33 further including a layer of SiGe over said layer of p-type doped SiC, said p-type doped SiC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

41. The layered structure of claim 34 further including a layer of SiGe over said layer of n-type doped SiC, said n-type doped SiC/SiGe layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

42. A layered structure comprising:

a substrate having an upper surface of single crystalline Si, and

a layer of SiGeC over said upper surface,

said Si/SiGeC layer interface having an abrupt change in C concentration above

$1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å,

and wherein the oxygen in said SiGeC layer is less than  $1 \times 10^{17}$  atoms/cc.

43. The layered structure of claim 42 wherein said SiGeC layer is single crystalline.

44. The layered structure of claim 42 wherein said SiGeC layer is polycrystalline.



45. The layered structure of claim 42 further including a layer of Si over said layer of SiGeC, said SiGeC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.
46. The layered structure of claim 42 wherein said layer of SiGeC includes a p-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc and wherein said p-type dopant profile can withstand furnace anneals to temperatures of 850° C and rapid thermal anneal temperatures to 1000° C.
47. The layered structure of claim 42 wherein said layer of SiGeC includes a n-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc.
48. The layered structure of claim 46 further including a layer of Si over said layer of p-type doped SiGeC, said p-type doped SiGeC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.
49. The layered structure of claim 48 wherein said p-type doped SiGeC/Si layer interface having an abrupt change in dopant concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å.

50. The layered structure of claim 47 further including a layer of Si over said layer of n-type doped SiGeC, said n-type doped SiGeC/Si layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said Si layer is less than  $1 \times 10^{17}$  atoms/cc.

51. The layered structure of claim 50 wherein said n-type doped SiGeC/Si layer interface having an abrupt change in dopant concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å.

52. The layered structure of claim 42 further including a layer of SiGe over said layer of SiGeC, said SiGeC/SiGe layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

53. The layered structure of claim 46 further including a layer of SiGe over said layer of p-type doped SiGeC, said p-type doped SiGeC/SiGe layer interface having an abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

54. The layered structure of claim 47 further including a layer of SiGe over said layer of n-type doped SiGeC, said n-type doped SiGeC/SiGe layer interface having an abrupt change in C

concentration above  $1 \times 10^{18}$  atoms/cc over a layer thickness in the range from about 6 Å to about 60 Å and wherein the oxygen in said SiGe layer is less than  $1 \times 10^{17}$  atoms/cc.

55. A layered structure comprising:

a substrate having an upper surface of single crystalline Si, and

a multitude of layers of materials selected from the group consisting of Si, SiGe,

SiC, and SiGeC over said upper surface,

said Si/SiC, Si/SiGeC, SiGe/SiC and SiGe/SiGeC layer interfaces having an

abrupt change in C concentration above  $1 \times 10^{18}$  atoms/cc over a layer

thickness in the range from about 6 Å to about 60 Å,

and wherein the oxygen in said carbon containing layer is less than  $1 \times 10^{17}$

atoms/cc.

56. The layered structure of claim 55 wherein said layers are single crystalline.

57. The layered structure of claim 55 wherein said layers are polycrystalline.

58. The layered structure of claim 55 wherein said carbon containing layers include a p-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc and wherein said p-type dopant profile can withstand furnace anneals to temperatures of 850° C and rapid thermal anneal temperatures to 1000° C.

59. The layered structure of claim 55 wherein said carbon containing layers include a n-type dopant in the range from about  $1 \times 10^{18}$  to about  $1 \times 10^{21}$  atoms/cc.